NOAA CO-OPS Continuous Global Navigation Satellite Systems at NWLON Stations

System Design Description

Bob Heitsenrether
Kevin Harrison
Eric Breuer

Engineering Division
Center for Operational Oceanographic Products and Services
NOAA National Ocean Service

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1. Introduction

NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) is modernizing techniques for monitoring and measuring sea level sensor elevation by establishing continuous Global Navigation Satellite Systems (cGNSS) directly at National Water Level Observing Network (NWLON) stations. From June 2018 to July 2019, CO-OPS established long-term cGNSS stations at six different NWLON sites: Virginia Key, FL; Galveston, TX; Dahlgren, VA; Newport, RI; San Juan, Puerto Rico; Pensacola, FL. The purpose of this document is to describe the system design details of the cGNSS stations that CO-OPS has established to date [1-6].

This design document focuses on the following system components: GNSS receiver, GNSS antenna, power system, communications system, and data telemetry methods. Details of antenna mounting hardware used at CO-OPS installed cGNSS stations to date are not discussed here since features vary with each site. Site specific details of each station's installation can be found in field installation reports [1-6]. Also, it should be noted that antenna siting and installation methods are still a work in progress.

At the time this document was written, all of the six cGNSS field stations that have been installed by CO-OPS consist of Trimble brand components. Based on an updated review of commercial-off-the shelf available GNSS equipment, CO-OPS has recently procured several Septentrio brand GNSS systems, for future installations at NWLON sites. Familiarization, integration and testing with Septentrio components remains a work in progress. This first version of CO-OPS cGNSS system design document will focus solely on Trimble based systems. This will be an evolving document that gets revised and reissued following CO-OPS implementation of new cGNSS station components.

2. System Requirements

The following is a summary of top level cGNSS measurement requirements for CO-OPS primary applications of interest. These requirements are the foundation for the GNSS receiver configuration settings and data-telemetry schemes described in the following sections:

- Satellite data sampling rate: 30s (in part based on results in reference 7)
- Satellites tracked: GPS and GLONASS
- Raw log file size: 24 hrs (daily based on GMT time, covering 00:00:00 - 23:59:30)
- Data telemetry frequency: once per day
- Data files telemetered: raw .T02 files (Trimble proprietary binary format)
- Aside from physical location, the GNSS system will be standalone and independent of the NWLON system, in terms of power, data logging and telemetry, so as not to interfere with NWLON operation.
- A best attempt should be made to collocate the GNSS antenna with the NWLON stations primary water level sensor (required for data to be used for sensor stability monitoring).

Requirements associated with vertical reference measurements to be obtained via level survey are discussed in a separate document [8].

3. System Design

The schematic in figure 1 provides a high level overview of cGNSS system design for all CO-OPS installations to date. The system's primary components can be classified into 3 categories:

1) GNSS Measurement System: receiver, antenna
2) Communications: Wireless gateway modem, antenna
3) Power: Solar panel, batteries, charge regulator

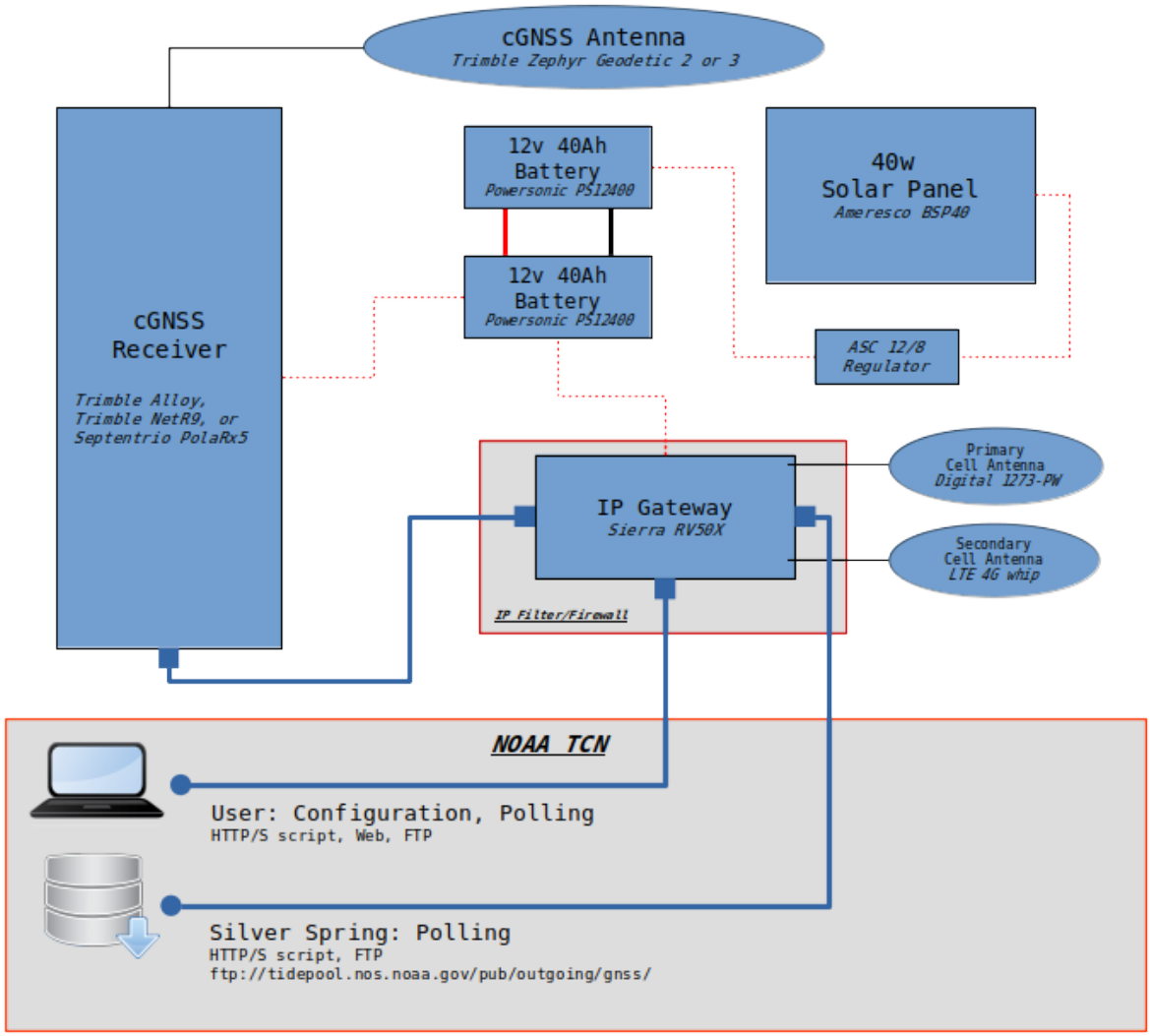


***Figure 1**. cGNSS system design schematic.*

3.1 GNSS System Receiver and Antenna

Trimble components have been used in all CO-OPS cGNSS field stations to date. Receiver models used include both the NetR9 and Alloy. During 2018, Trimble discontinued the NetR9 model receiver and then offered the Alloy as a replacement. The Alloy is very similar to the NetR9, just with a few enhancements. All differences are relatively minor in the context of CO-OPS applications. The software, firmware and associated user interface for both receivers is close to identical. As such, only one description of receiver software configuration, relevant to both units, is documented below. Detailed technical specifications provided by the vendor for both receiver models are included as appendices A and B.

All of CO-OPS' NetR9s and Alloys are equipped with firmware versions 5.3 or higher, which includes capabilities to track GPS, GLONASS, SBAS, Galileo, BeiDou and QZSS constellations. Currently, receivers are configured to track only GPS (L1/L2/L5) and GLONASS (L1/L2/L3) signals based on requirements listed above (and in part driven by CO-OPS and NGS limited processing capabilities).

Two different types of Trimble antennas have been used across the 6 different field installations - the Zephyr Geodetic II and III. Similar to the two different model receivers, technical differences between the two antennas can be considered minimal for CO-OPS applications of interest.

3.1.1 Trimble NetR9 GNSS Receiver

Figure 2 shows annotated pictures of the front and back panels of the NetR9 receiver. The front panel offers a simple display screen and a control pad for checking system status and configuration settings in the field. Although the front panel control pad offers basic capabilities to change receiver settings, it is recommended that it is not used for this purpose. For CO-OPS applications, configuration settings should only be changed via laptop interface and the receivers web user interface or programmatic interface.

The back panel includes all receiver ports and connectors for power, communications, and GNSS antenna interface. Detailed labels are included in figure 2 and cabling is discussed in more detail in section 3.4.

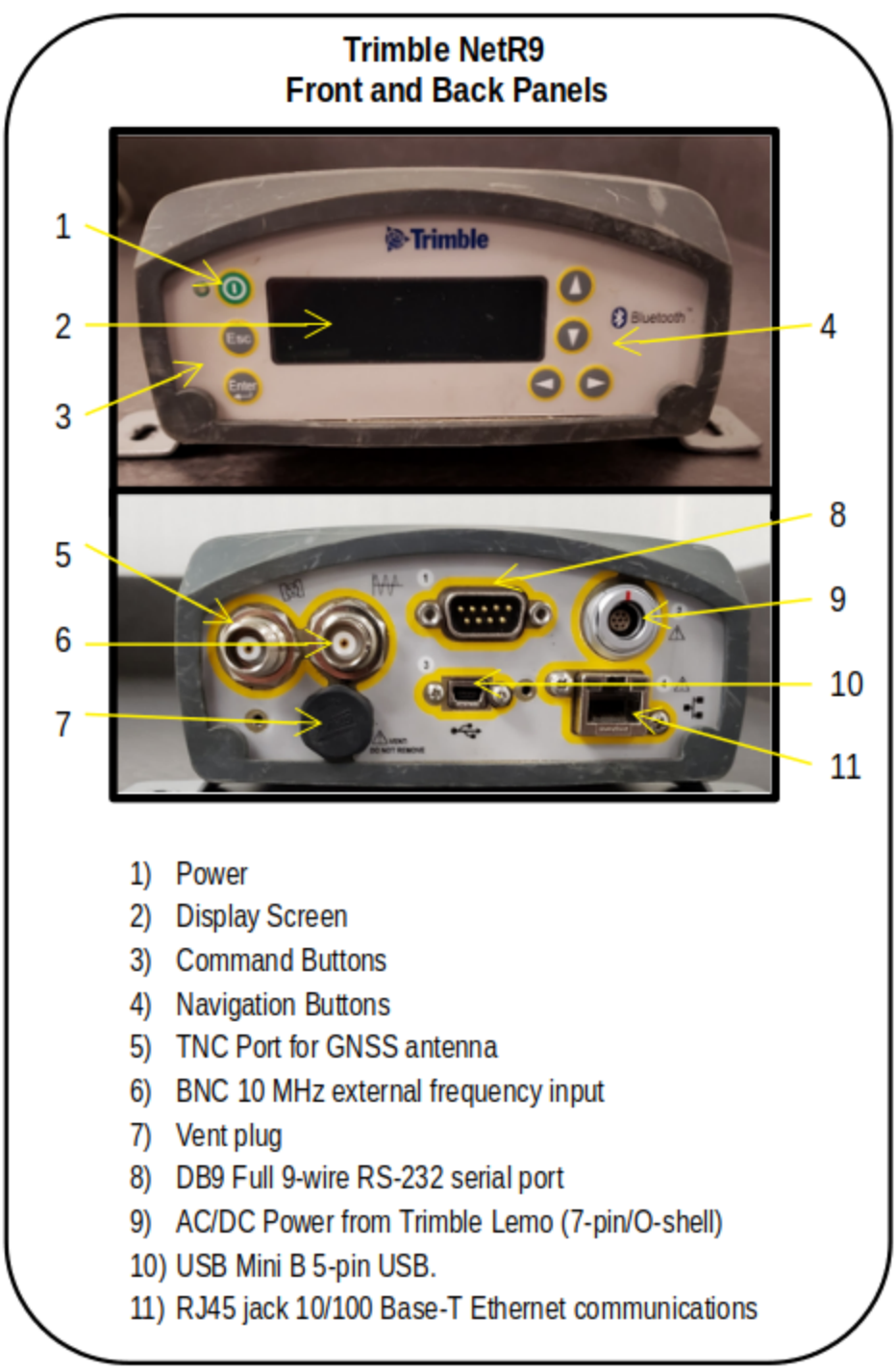


***Figure 2**. Trimble NetR9 Receiver, front and back panels.*

Additional details on the NetR9 receiver can be found on the UNAVCO NetR9 resource page [9].

3.1.2 Trimble Alloy GNSS Receiver

Figure 3 shows annotated pictures of the front and back panels of the Alloy receiver. The Alloy was officially released as the replacement for the NetR9 during January 2018. The Alloy is essentially an updated improved version of the NetR9 with enhanced features including a ruggedized IP68 housing, modernized satellite tracking, and additional software updates that allow use as as a campaign receiver for post-processing, portable base station for Real-time Kinematic (RTK) applications, or as a scientific reference station. For all of CO-OPS GNSS applications of interest, most user interface and software configuration settings for the Alloy will be identical to those of the NetR9.

Similar to the NetR9, the front panel includes a simple display and basic control buttons. The setup of the back panel ports and connectors are slightly different than those of the NetR9 as shown in figure 3 pictures and annotations.

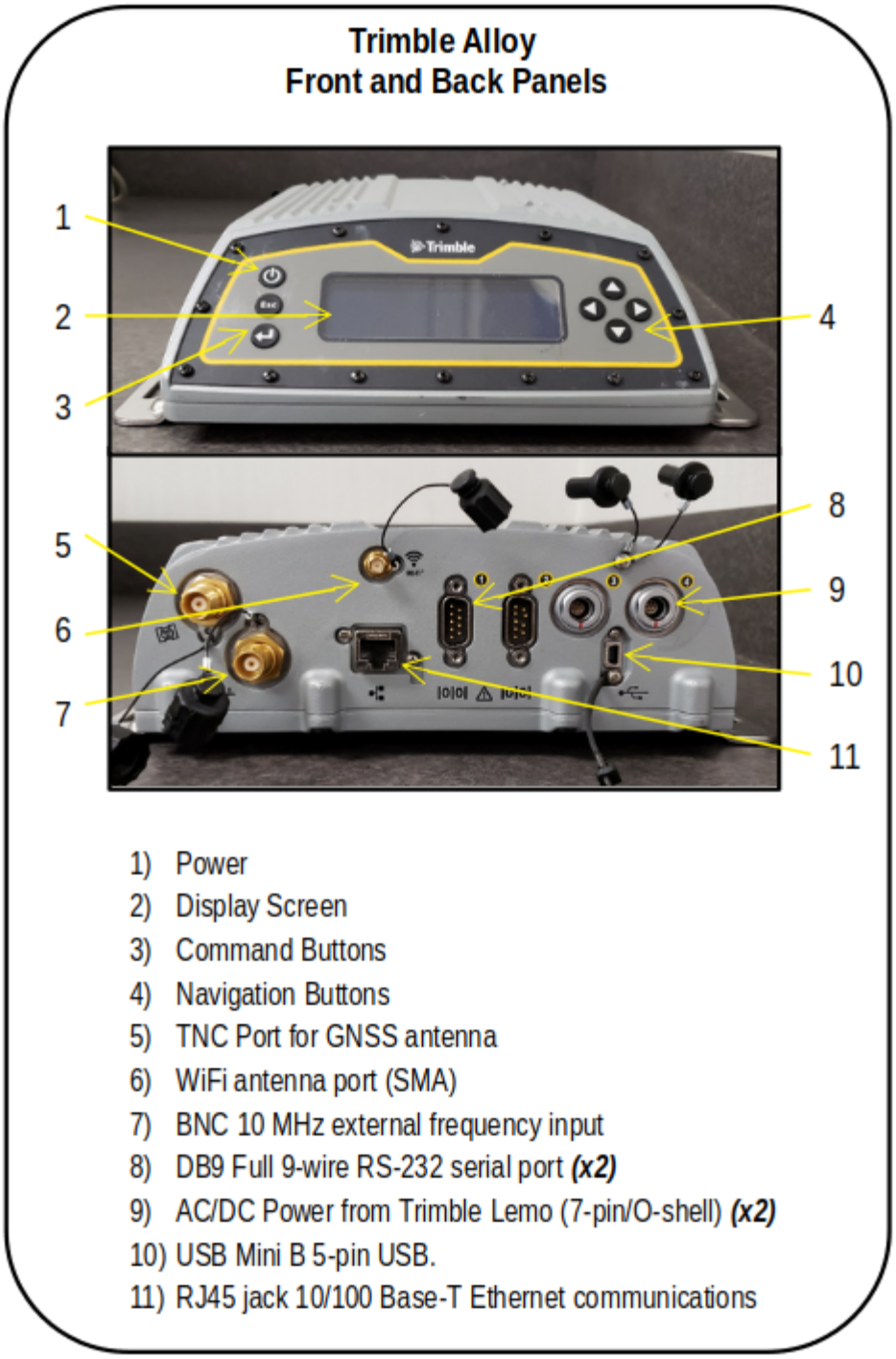


***Figure 3**. Trimble Alloy Receiver, front and back panels.*

One noteworthy enhancement to the Alloy is the addition of a built in wifi capability. When enabled, this allows any nearby user with a PC, recognized CAC ICC, receiver encryption code, and two step verification credentials to easily connect the receivers web user interface or programmatic interface. The Alloy wifi connection provides a

convenient interface option for initial system configuration in the laboratory, or for checking the system status immediately following field installation. Before a field installed system is to be left for long term data collection, the wifi capability must be disabled to reduce power consumption.

3.1.3 Trimble Zephyr Geodetic Antennas

CO-OPS cGNSS field installations have included both Zephyr Geodetic (ZG) II and III model antennas. Similar to receivers, the ZG III is just an improved version of the ZG II. The majority of updates to the ZG III are associated with internal electronics and firmware. The external components and appearance of both models are close to identical.

The following ZG antenna features in part resulted in selection for CO-OPS applications:

- Full GNSS tracking; GPS, GLONASS, Galileo, Beidou, QZSS
- Robust low elevation satellite tracking
- Minimized multipath
- Sub-millimeter phase center to antenna reference point (ARP) calibration
- Ideal for fixed/static reference stations
- Improved signal reception in harsh signal environment
- Lightweight supports collocation with primary NWLON water level sensor

Figure 4 shows photos of the top and bottom of a Zephyr Geodetic II antenna, with key components labelled. Major features are similar on the ZG model III.

The two most important differences between the two antenna models to be addressed by the user:

1. Antenna type ID numbers are different. The correct ID must be selected when configuring the receiver. ID number for the ZG II is TRM55971.00 and for the ZG III is TRM115000.00.
2. The vertical position between the phase center and ARP is different for each model. The vendor provided offset is printed on the back of each antenna as shown in Fig. 4. Correct selection is critical for a variety of different vertical reference applications.

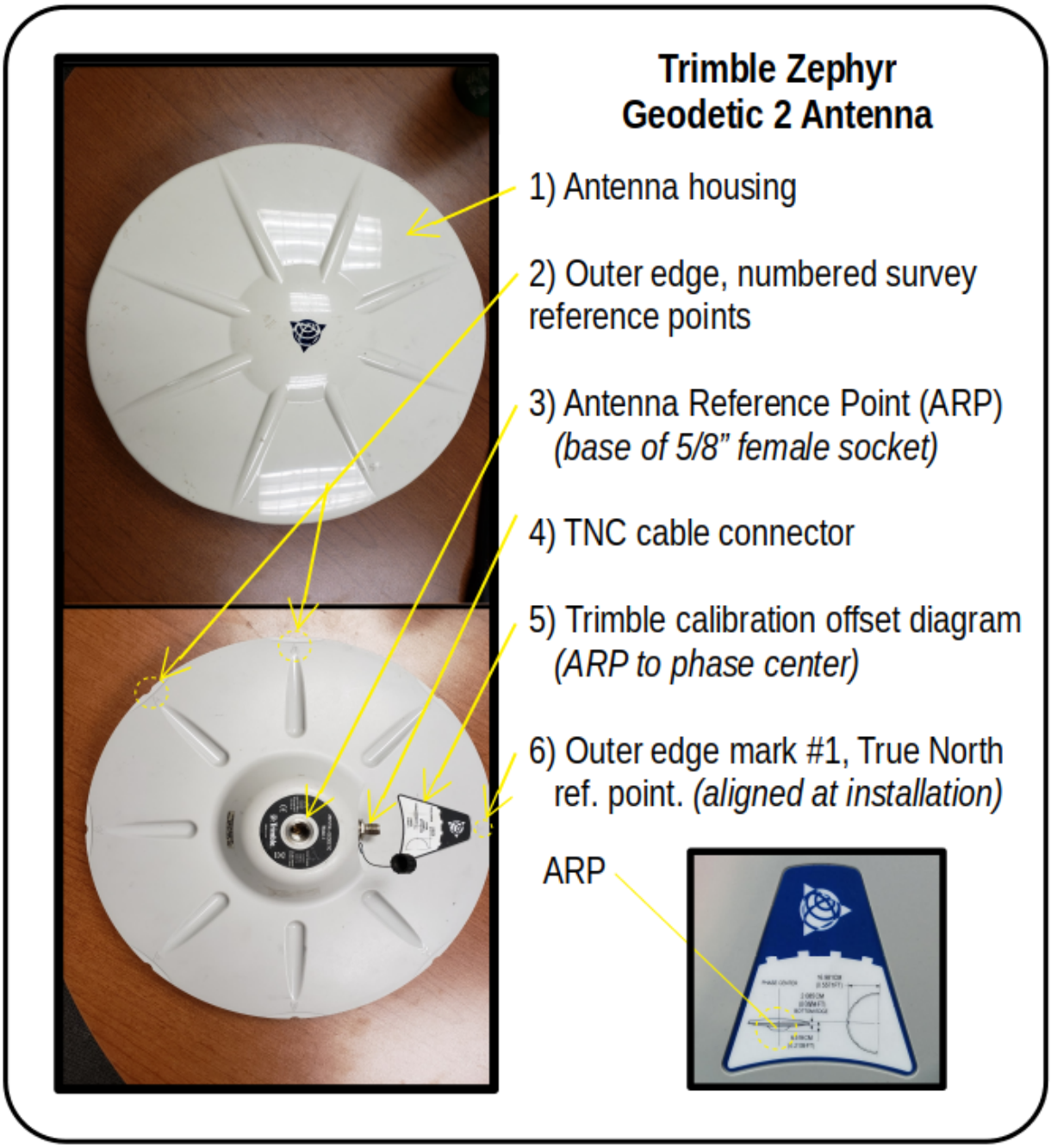


***Figure 4**. Top and bottom of Zephyr Geodetic 2 antenna.*

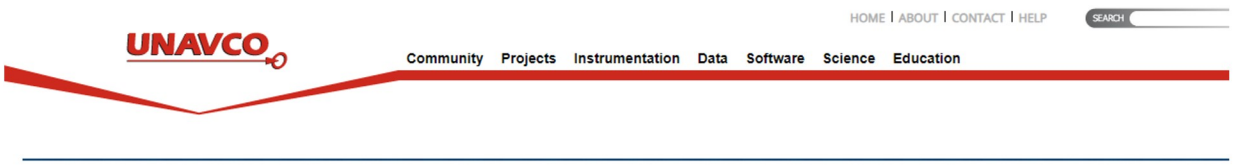
At all six CO-OPS GNSS stations, a SECO brand Adjustable Tilt Monument Adapter was used to mount the ZG antennas atop a mast, consisting of either 1.5 inch or 2 inch pipe. Figure 5 shows a picture of the SECO adapter and an example field installation. SECO adapter features include:

- A removable brass 5/8 x 11 male stud (threads to antenna base) that is adjustable in azimuth.
- The 5/8 x 11 male stud is held in location by two set screws.
- The adapters are leveled by three adjusting screws with a tilt range of +/- 7 degrees
- The adapter has a female base that is threaded to match the male pipe used.(available in 1.5", 2", 3" MPT, or 5/8 x 11 thread)

***Figure 5**. SECO adapter.*

3.1.4 Receiver Configuration Settings

The starting point for receiver configuration was a standard UNAVCO setup file with GPS and GNSS tracking. UNAVCO configuration files for the Trimble receivers are available from the web site link listed in reference 10. Figure 6 is a capture from the UNAVCO website showing a listing of the available configuration file options for the Trimble receivers. Based on measurement requirements listed in section 2 above, UNAVCO option “A” is used for CO-OPS cGNSS systems.



Session Name	Sample Rate	Duration	Enabled	Pool	File System	Path Style	Name Style	FTP Push	Email Push
DEFAULT	15 sec	1440 min	No	Delete when full 1000 MB (– 1000 days)	Internal	YYYYMM/Session	##########YYYYMMDDhhmm	No	No
A	30 sec	1440 min	Yes	Delete when full 2000 MB (–800 days)	Internal	YYYYMM/Session	##########YYYYMMDDhhmm	No	No
B	1 sec	60 min	Yes	Delete when full 1500 MB (–36 days)	Internal	YYYYMM/Session	##########YYYYMMDDhhmm	No	No
a_ext	30 sec	1440 min	No	Delete when full 2000 MB (–800 days)	External	YYYYMM/Session	##########YYYYMMDDhhmm	No	No
b_ext	1 sec	60 min	No	Delete when full 2000 MB (–48 days)	External	YYYYMM/Session	##########YYYYMMDDhhmm	No	No

***Figure 6**. UNAVCO configuration file options for the Trimble receivers.*

The UNAVCO configuration clone file is downloaded from the reference website and uploaded to the receiver through the receiver web interface. Figure 7 shows the Trimble receiver web interface home screen that appears upon initial connection (top) and figure 8 shows the programmatic interface home screen.

The UNAVCO configuration clone file is uploaded to the Trimble receiver following these steps:

- Select ***Receiver Configuration***
- Select ***Application Files***
- Choose ***Upload Install Clone File*** from the ***Operation*** menu.
- Select the configuration file that you would like to upload.
- Select ***OK***

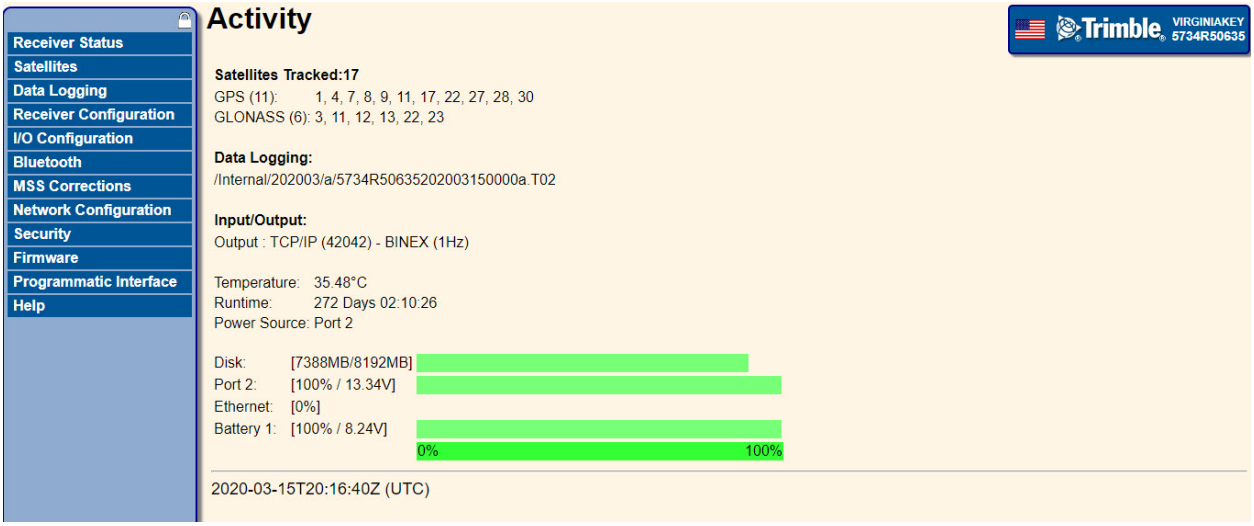


***Figure 7**. Trimble receiver (NetR9 and Alloy) web interface home screen.*

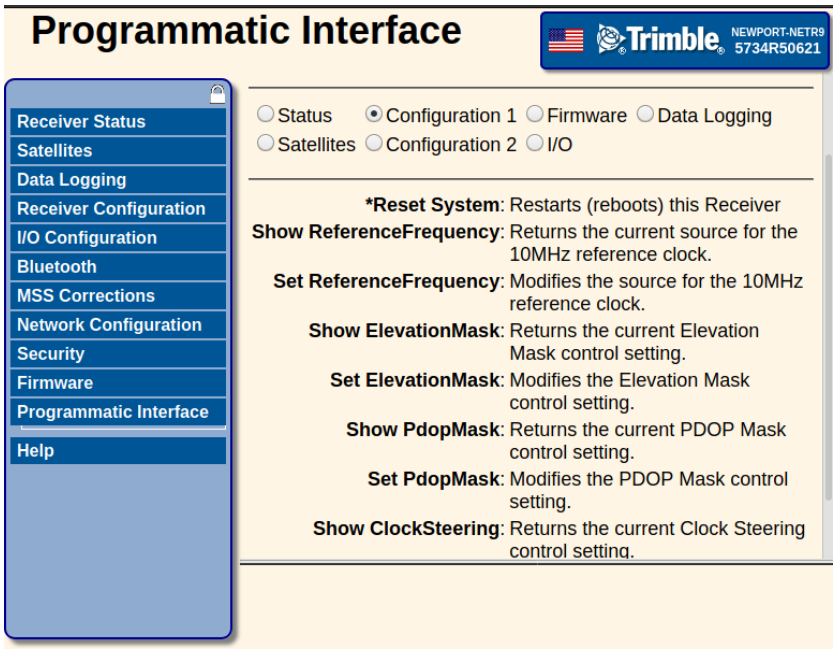


***Figure 8**. Trimble receiver (NetR9 and Alloy) programmatic interface home screen.*

Figure 9 shows the Trimble receiver screen that summarizes the key settings of the UNAVCO standard configuration file.

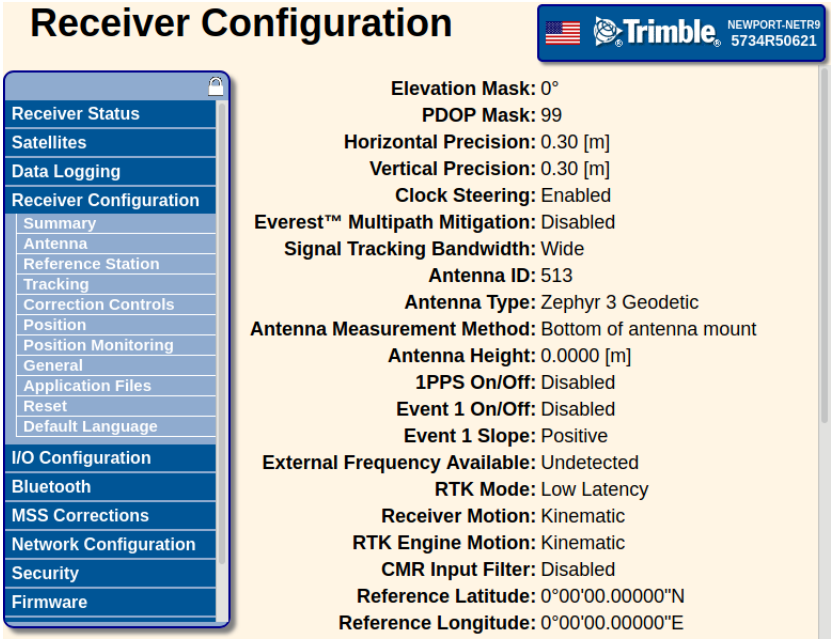


***Figure 9**. Listing of key settings associated with the UNAVCO standard configuration file.*

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After uploading the configuration file, several additional features are modified or enabled/disabled through the ***Receiver Configuration*** menu. Most important is adjusting power to better handle CO-OPS' remote DC powered installations, maximizing battery life and low-power operation. Figure 10 shows adjusted power configuration settings on the ***Receiver Configuration*** -> ***General*** tab***.***

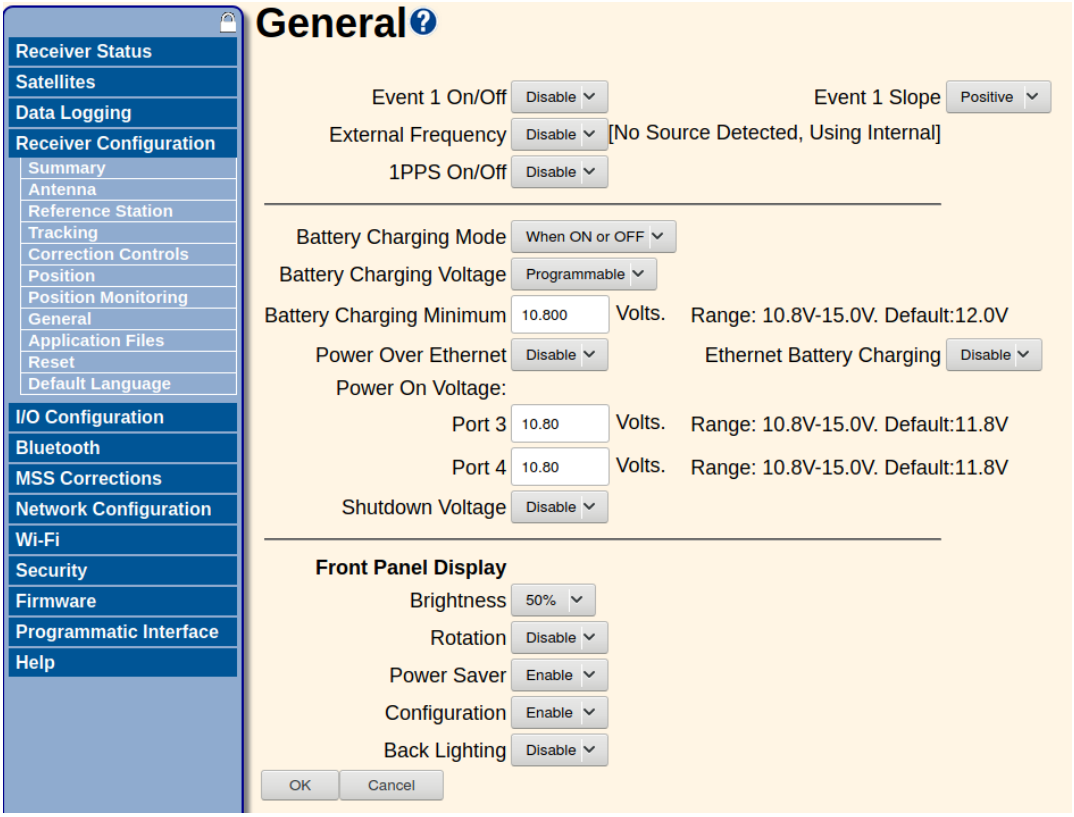


Figure 10. *Trimble receiver web interface tab where power configuration settings are adjusted.*

3.2 Communications System

As shown in the high level system design schematic at the beginning of section 3 (fig 1), the primary communications component of CO-OPS cGNSS field systems is a cellular gateway, also commonly referred to as an internet protocol (IP) modem. The specific make/model modems used with cGNSS systems are the same models that are employed throughout CO-OPS PORTS and NWLON stations, the Sierra Wireless RV50 and RV50X. CO-OPS' Chesapeake Instrumentation Laboratory (CIL) configures the cGNSS IP modems with the same settings as those used with modems for NWLON and PORTS stations, and with identical security filters installed. All cGNSS stations IP modems are provisioned with Verizon or AT&T. Due to the large file sizes and the unique polling system, a special 5GB data plan must be specified for these devices when provisioning. Figure 11 shows pictures of the RV50 IP modem with key components labelled.

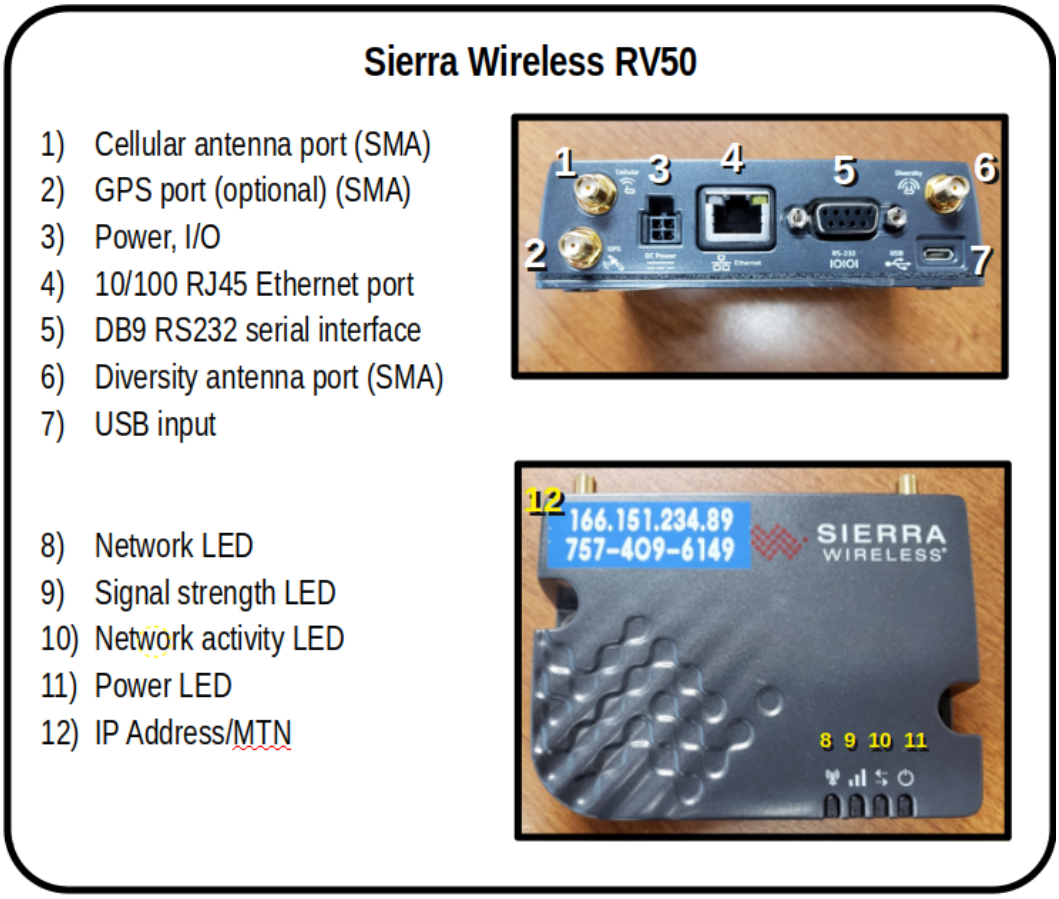


Figure 11. *RV50/RV50X IP modem.*

The RV50X is designed to withstand harsh industrial conditions and is capable of surviving 5 V brownouts and spikes from -600 VDC to 200 VDC. Its die cast aluminum housing is sealed to meet IP64 standards for resistance to dust and water ingress. The RV50X is tested to meet and exceed the MIL-STD-810G specification for shock, vibration, temperature and humidity. The RV50X is optimized for battery and solar applications, operating at 900 mW in idle mode. More information on power specifications is included section 3.3.

Two antennas are used with RV50 in cGNSS installations: a Digital Antenna PW-1285 Wide band 4G antenna and a dual band paddle diversity antenna.

The Trimble receiver's Network configuration settings selected for IP modem integration are summarized in the NetR9/Alloy web interface screen captures displayed in figure 12.

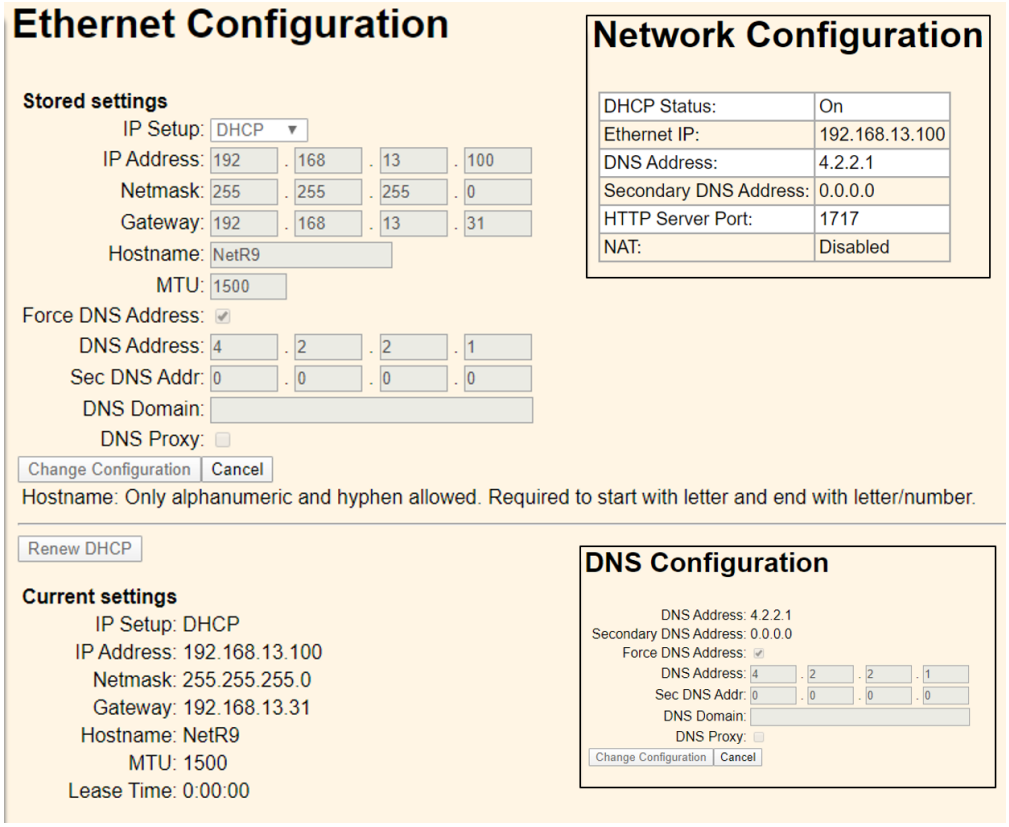


Figure 12. *Trimble receiver network configuration settings used for IP modem integration.*

3.3 Power System

An estimated power budget for CO-OPS' Trimble based cGNSS field system is summarized in Table1. All results in the table are based on manufacturer specifications, not actual measurements. The systems estimated total average current and daily power load, along with a desire to use some power system components that are standard to NWLON and PORTS inventory, led to the selection of the following power system primary components:

- 2 Powersonic 12400 12VDC, 40 Ah sealed gel batteries (wired in parallel)
- 1 Ameresco 12VDC, 40W solar panel
- 1 ASC 12VDC 8A Solar regulator

As documented in references 1 and 2, during the CO-OPS initial cGNSS design process (in early 2018) a 50W solar panel was recommended for the power system. However, this was guided by a power budget based on specifications of a Sierra Wireless modem model that preceded the RV50 series. Updating the system with the

more efficient RV50 significantly reduced the total system power load, resulting in the selection of the 40W panel.

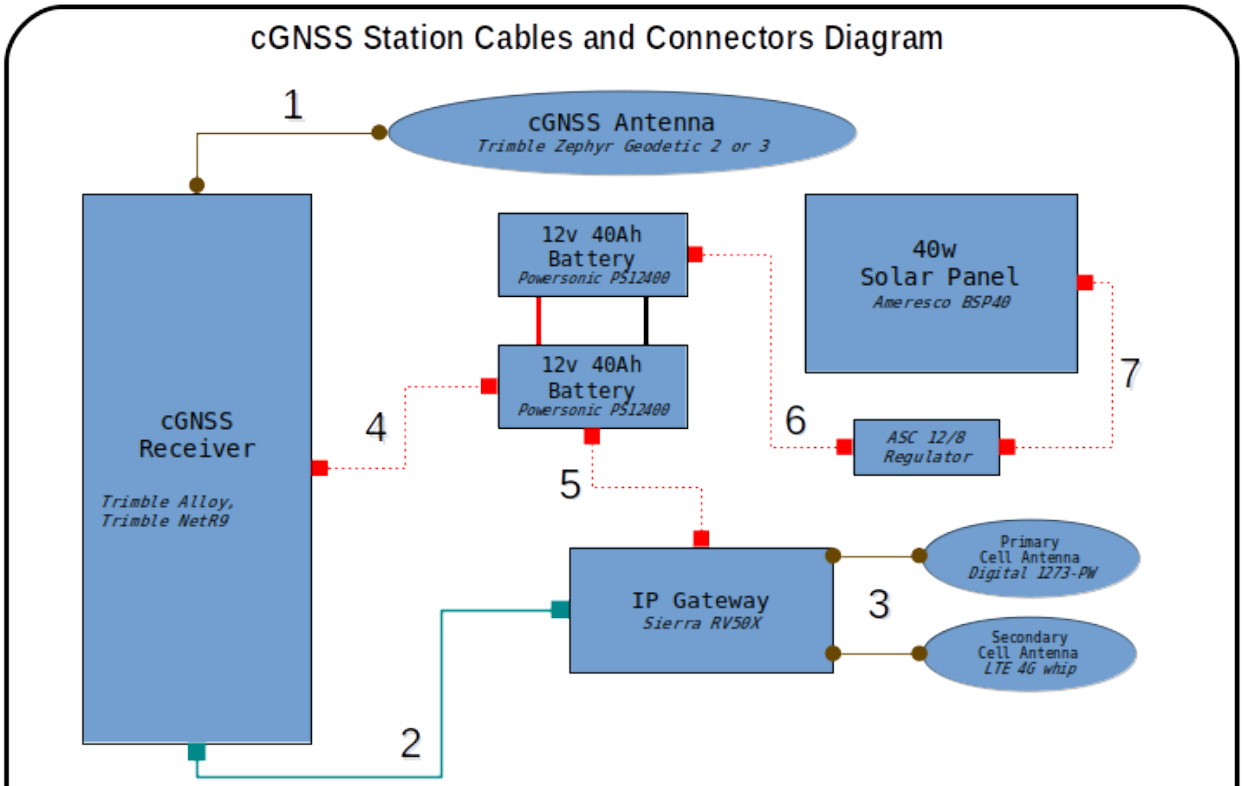
As summarized in table 1, it is estimated that the cGNSS system could run for approximately 9 days in the event of an unexpected loss of charge, for example during a period of prolonged cloud cover. Also, the Alloy and NetR9 have an additional internal battery installed which would result in an additional 18-24 hrs of operation following the stop of external power supply.

Table 1. *Estimated power budget for Trimble based cGNSS field system.*

Trimble cGNSS Power Budget					
			Average Current Load		
Item	**Current (mA)**	**Active Time (s/day)**	**% Active**	**Ave. Current (mA)**	**NOTES**
Trimble GNSS Reciever	316	86400	100.00	316.00	
Sierra RV50X active	400	30	0.03	0.14	*Active only during polling or remote connection*
Sierra RV50X idle	75	86370	99.97	74.97	
				391	Total Average Current (mA)
			Power Consumption		
Power = Total Average Current Times 12 Volts				4.69	Total Average Power (@ 12 V) Watts
Energy Used Daily = Total Average Power Times 24 Hours				112.64	Total Daily Power Load (Wh)
Amp Hours Used Daily = Total Average Current Times 24 Hours				9.39	Total Daily Ah Usage
			Battery Capacity		
Battery Capacity	40	Ah	2X Powersonic 12400 12v 40Ah		
Quantity	2				
Daily Ah Usage	9.39	Ah/Day	Total Daily Ah Usage		
Capacity in Days	9	Days	Capacity divided by Usage		

3.4 Cables, Connectors, Wiring

The diagram and table in figure 13 provides a detailed description of all cGNSS station cables, wiring, and connections. Connectors in figure 13 correspond to labelled components in figures 2,3,4, and 11.



#	Connection 1 *(low loss where applicable)*	Cabling *(low loss where applicable)*	Connection 2 *(low loss where applicable)*
1	NetR9/Alloy TNC-F connector	RG58,RG213 or better coaxial cable (LMR240, 400 recommended)	Zephyr Geodetic II/III TNC-F connector
2	NetR9/Alloy RJ45 Ethernet port	RJ45 CAT5 patch cable	Sierra Wireless RV50 RJ45 Ethernet port
3	RV50 IP Modem SMA-F antenna connector	RG58, 50Ω RG213/U coaxial cable	4G SMA-F (or N-type) Antenna port
4	NetR9/Alloy 7-pin Power	Trimble 59044: 0S/7P/M / Power Cable	Powersonic Battery Terminals
5	Sierra Wireless Power	Sierra Wireless 4 port power/IO cable	Powersonic Battery Terminals
6	Powersonic Battery Terminals	Carol 16AWG 2 conductor power cable	ASC 12/8 Charge Regulator Output Terminals
7	Ameresco Solar Panel Terminals	Carol 16AWG 2 conductor power cable	ASC 12/8 Charge Regulator Input Terminals

Figure 13. *cGNSS station cabling and connector diagram.*

3.5 Data Telemetry

In accordance with requirements summarized in section 2, the Trimble cGNSS receivers are configured to log GPS and GLONASS satellite track observations at a 30 second sample rate and data are recorded in 24 hour (daily) log files. Log files are in a proprietary Trimble binary format (*.T02 extension).

The daily binary *.T02 files are stored locally on the device and retrieved daily from servers in Silver Spring. A custom HTTPS script, developed by ED and ISD, is used to connect to the GNSS receiver via-internet and transfer files once per day . SSEB is currently researching other protocols for file transfer (FTP Push, SSH and SFTP). These changes will become necessary with our migration to Septentrio receivers, and as NOAA security requirements become more stringent.

Daily binary files are converted to RINEX on CO-OPS servers upon ingestion. Raw binary files and converted RINEX files are all available on a CO-OPS intranet site:
https://intranet.nos-tcn.noaa.gov/apps/cdis/gnss/
And a public ftp site:
ftp://tidepool.nos.noaa.gov/pub/outgoing/gnss/

Details of data archival, sharing, and processing will be discussed in a separate document.

4. References

1. CO-OPS ED Report - Installation of cGNSS at Virginia Key, FL NWLON Station, Jun 2018 https://drive.google.com/file/d/1NxiOWTOcuxI_F_LmOwUwWFZfAFfQTK-X/view
2. CO-OPS ED Report - Installation of cGNSS at Galveston, Pier 21, TX NWLON Station Aug 2018 https://drive.google.com/file/d/1WVlospA_rSusSH3IvjDsYUX0vDPw_D4Y/view
3. CO-OPS ED Report - Installation of cGNSS at Dhalgren, VA NWLON Station Oct 2018 https://drive.google.com/file/d/1XYmuqSnm_zBpeCmQ5pIjNKrsCm1Dvta7/view
4. CO-OPS ED Report - Installation of cGNSS at Newport, RI NWLON Station, Nov 2018 https://drive.google.com/file/d/1gBugcRiAjD4wQETaP7DpcoXHMoLOhNcz/view
5. CO-OPS ED Report - Installation of cGNSS at San Juan, Puerto Rico NWLON Station, Jul 2019 https://drive.google.com/file/d/1yRBjLNRxYC2nspkyt7Ib5HCZY4ASRQx6/view
6. CO-OPS ED Report - Installation of cGNSS at Pensacola, FL NWLON Station, Aug 2019 https://drive.google.com/file/d/1TSuI5pbWV-Ywh56YgCnNmv97WCCLOjN9/view
7. Jamieson, Marian & Gillins, Daniel. (2018). Comparative Analysis of Online Static GNSS Postprocessing Services. Journal of Surveying Engineering. 144. 10.1061/(ASCE)SU.1943-5428.0000256.
8. CO-OPS ED Report - Field Level Survey Procedures for CO-OPS Installed cGNSS (in draft) - Mar 2020
9. UNAVCO Trimble NetR9 resources page: https://kb.unavco.org/kb/article.php?id=673
10. UNAVCO Trimble Configuration site: https://kb.unavco.org/kb/article/unavco-standard-configuration-file-for-the-netr9-772.html

APPENDIX A - Trimble NetR9 spec sheet

NetR9

GNSS REFERENCE RECEIVER SERIES

The Trimble NetR9 Global Navigation Satellite System (GNSS) reference receiver series consists of full-feature, top-of-the-line receivers designed to provide network operators with maximum features and functionality from a single receiver platform.

Using the latest generation of Trimble 360 receiver technology in combination with two Trimble Maxwell™ 6 chipsets, the Trimble NetR9 reference receiver offers an industry-leading 440 channels for unmatched GNSS multi-constellation tracking performance. With the world's GNSS in constant development, the Trimble NetR9 reference receiver provides the operator with the assurance that it has the capability to grow with the industry, both today, and well into the future.

The Trimble NetR9 reference receiver supports a wide range of satellite signals. Currently, the NetR9 platform is capable of tracking signals from GPS, GLONASS, Galileo[1], Beidou, and QZSS constellations. With 440 channels, the NetR9 has the capacity to accommodate additional signals as they may become available, eliminating the need to replace hardware to keep pace with technology[2].

The Trimble NetR9 reference receiver supports the new CMRx communications protocol, which provides unprecedented GNSS correction compression for optimized bandwidth and low latency data transmission. Combined, this results in greater data throughput at a lower operating cost.

The Trimble NetR9 reference receiver's compact form factor, low power consumption and powerful network capabilities make for an ideal combination supporting a wide range of high-accuracy positioning applications. A few specific examples include:

- Trimble VRS™ network receiver
- Mobile field base station
- Academic research
- Continuously Operating Reference Station (CORS)
- Field campaign receiver for post-processing applications
- Use in DGPS MSK beacon systems
- Monitoring integrity of VRS networks, along with other physical infrastructure such as oil platforms, mines, dams, bridges, or other natural and man-made objects where precise deformation is crucial

The Trimble NetR9 reference receiver has eight gigabytes of physical memory built into the circuit board, providing a high level of data protection. Additionally, the use of external USB logging devices is supported providing the Trimble NetR9 reference receiver unparalleled storage capacity and flexibility. Combined with logging of T02, RINEX, BINEX, and Google Earth formats, factored together with FTP and Email Push technology, the Trimble NetR9 achieves an uncompromised blend of functionality and efficiency.

With stringent environmental specifications and an integrated lithium-ion, the Trimble NetR9 protects to ensure no data is missed. The integrated Li-Ion battery can power the Trimble NetR9 continuously up to 15 hours, either as a primary power source or as an emergency backup source.

The Trimble NetR9 reference receiver comes with powerful built-in remote management. Utilizing Internet Protocol (IP) as the primary communications mechanism, the familiar Trimble Infrastructure web user interface provides full receiver status, configuration, firmware updates, data access, as well as a variety of security levels and access controls. Furthermore, the receiver supports Email Alerts so the operator knows exactly what is taking place at the receiver. This includes integrated position monitoring so as to always know if your antenna has moved before it is too late.

For simple hands-on configuration, the Trimble NetR9 reference receiver offers a seven-button, two line display and status information so that performing in-field configuration is practically effortless. Best of all, no handhelds are required to get this job done.

Available in three upgradable configurations (NetR9 Ti-1, Ti-2, and Ti-3) along with one non-upgradable configuration (NetR9 Ti-M), the NetR9 provides the most flexible receiver platform offered to date. With the NetR9 receiver platform's robust functionality, you can trust Trimble to provide the very latest technology in the GNSS industry to help position your way into the future.

Key Features

- Proven GNSS technology from Trimble
- 440 channels for unmatched GNSS tracking performance
- Bluetooth®, Ethernet, Serial and USB support
- Position Monitoring and Alerting functionality notifies of any change in antenna position
- Large capacity internal memory plus external USB device logging capability
- Convenient front panel display and configuration
- Power over Ethernet (PoE) technology
- Twelve independent logging sessions
- Multiple data file formats
- Integrated battery which can act as a primary power source or as an uninterrupted power supply (UPS) backup
- Powerful remote configuration and access
- Trimble RTX™ World Wide Correction Service ready

1 Developed under a License of the European Union and the European Space Agency.
2 For more information about Trimble and GNSS modernization, please visit http://www.trimble.com/srv_new_era.shtml

PHYSICAL SPECIFICATIONS

Dimensions (L x W x H)	26.5 cm x 13.0 cm x 5.5 cm (10.43 in x 5.12 in x 2.16 in)
Weight	1.75 kg (3.85 lb)

ENVIRONMENT

Certification	IP67 and MIL-STD 810F
Operating temperature[11]	–40 °C to +65 °C (–40 °F to +149 °F)
Storage temperature	–40 °C to +80 °C (–40 °F to +176 °F)
Humidity	100% condensing
Shock	Survival: Non-operating 75 g, 6 mS; Operating: to 25 g, 10 ms, sawtooth; designed to survive a 1 m drop onto hard surface
Vibration	Operating: 2.6 g RMS. 7.5 Hz/0.015 g2/Hz; 350 Hz/0.015 g²/Hz; 500 Hz/0.006 g²/Hz Non-Operating: 4.3 g RMS. 10 Hz/0.04 g²/Hz; 300 Hz/0.04 g²/Hz; 1000 Hz/0.002 g²/Hz
Ingress protection	IP67; waterproof for temporary immersion to a depth of 1 m (3.28 ft); dustproof

USER INTERFACE

- Front Panel Display
  - 2-line x 16-character vacuum fluorescent display
  - Advanced power saving modes
  - Escape and Enter key for menu navigation
  - 4 arrow keys (up, down, left and right) for scrolling and data entry
  - Power button and indication LED
- Web User Interface
  - Secure
  - Allows remote configuration, data retrieval and firmware updates
- Programmatic Interface
  - Allows for open, non-proprietary access, control and configuration

ANTENNA SUPPORT

Output voltage	5.0 V DC nominal
Maximum output current	150 mA
Maximum cable loss	12 dB
Recommended antennas	Trimble Zephyr 3 Geodetic™, Trimble GNSS Choke Ring, Trimble GNSS-Ti Choke Ring, Ag25 (for use with Ti-M variant only)

SECURITY

- Optional HTTP login
- HTTPS
- Real-time stream authentication
- Programmatic interface authentication
- NTRIP

ELECTRICAL

- Power over Ethernet (PoE) 802.3af; requires a Class 3 PoE supply
- 9.5 V DC to 28 V DC input on Lemo port
- User-configurable power-on voltage
- User-configurable power-down voltage
- Integrated internal battery 7.4 V, 7800 mA-hr, Li-Ion; 15 hours of continuous operation, dependent on user settings
- Internal battery operates as a UPS in the event of power source outage
- Seamless switching between external/internal power sources
- Internal battery will charge from external power source when input voltage is >12 V DC
- Integrated charging circuitry
- Power consumption 3.8 W nominal, dependent on user settings

REGULATORY COMPLIANCE

- RoHS
- China RoHS
- FCC Part 15.247 FCC certifications
- Class B Device FCC Part 15 and ICES-003 compliance
- RSS-310 and RSS-210 Industry Canada compliance
- CE mark compliance
- C-Tick mark compliance
- UN ST/SG/AC.10.11/Rev. 3, Amend. 1 (Li-Ion battery)
- UN ST/SG/AC.10/27/Add. 2 (Li-Ion battery)
- WEEE

1 NetR9 available in four configurations: Ti-1, Ti-2, Ti-3, and Ti-M. Specifications shown reflect full configuration capability. Please consult your local distributor for additional information.
2 There is no public GLONASS L3 CDMA ICD. The current capability in the receivers is based on publicly available information. As such, Trimble cannot guarantee that these receivers will be fully compatible with a future generation of GLONASS satellites or signals.
3 Developed under a License of the European Union and the European Space Agency.
4 Current Beidou capability is based on publicly available information. The hardware of this product is designed for Beidou B3 compatibility (trial version) and its firmware will be enhanced, where possible, to fully support such new signals as soon as the officially published signal interface control documentation (ICD) becomes available. As such, Trimble cannot guarantee full compatibility with future generations of Beidou satellites or signals.
5 Pilot observable.
6 Accuracy and reliability may be subject to anomalies due to multipath, obstructions, satellite geometry, and atmospheric conditions. The specifications stated recommend the use of stable mounts in an open sky view, EMI and multipath clean environment, optimal GNSS constellation configurations, along with the use of survey practices that are generally accepted for performing the highest-order surveys for the applicable application including occupation times appropriate for baseline length. Baselines longer than 30 km require precise ephemeris and occupations up to 24 hr may be required to achieve the high accuracy static specification.
7 Depends on WAAS/EGNOS system performance.
8 Networked RTK PPM values are referenced to the closest physical base station.
9 Bluetooth type approvals are country specific. Contact your local authorized Trimble distribution partner for more information.
10 USB device minimum recommended specification must support USB 2.0 Hi-Speed with a minimum write speed of 6 Mbps. Solid state drives recommended for optimal performance.
11 The internal battery will operate from –20 °C to +55 °C (14 °F to +131 °F). The internal battery charger will operate from 0 °C to 45 °C (32 °F to 113 °F). All temperatures listed reference the ambient temperature.

SATELLITE TRACKING

- Two advanced Trimble Maxwell 6 GNSS chipsets for a total of 440 channels
- Trimble EVEREST™ multipath signal rejection
- Trimble 360 receiver technology
- Trimble R-Track™ technology
- High precision multiple correlator for GNSS pseudorange measurements
- Unfiltered, unsmoothed pseudorange measurements data for low noise, low multipath error, low time domain correlation and high dynamic response
- Proprietary Receiver Autonomous Integrity Monitor (RAIM) system to detect and reject degraded signals to improve position quality.
- Very low noise GNSS carrier phase measurements with <1 mm precision in a 1 Hz bandwidth
- Signal-to-noise ratios reported in dB-Hz
- Proven Trimble low elevation tracking technology
- Current satellite signals tracked simultaneously:
  - GPS: L1 C/A, L2C, L2E (Trimble method for tracking unencrypted L2P), L5
  - GLONASS: L1 C/A and unencrypted P code, L2 C/A and unencrypted P code, L3 CDMA[2]
  - Galileo[3]: L1 CBOC, E5A, E5B & E5AltBOC
  - Beidou[4]: B1, B2, B3
  - QZSS: L1 C/A, L1C, L1 SAIF, L2C, L5, LEX[5]
  - SBAS: L1 C/A (EGNOS/MSAS), L1 C/A and L5 (WAAS/GAGAN)
  - L-Band: OmniSTAR VBS, HP and XP
  - Trimble RTX World Wide Corrections

INPUT/OUTPUT FORMATS

- Correction Formats:
  - CMR, CMR+, CMRx, RTX, RTCM 2.1-3.2 and MSM
- Observables:
  - RT17, RT27, BINEX, RTCM 3.x
- Position/Status I/O:
  - NMEA-0183 v2.30, GSOF
- Up to 50 Hz Output
- 10 MHz External Frequency Input
  - Normal input level 0 to +13 dBm
  - Maximum input level +17 dBm, ±35 V DC
  - Input impedance 50 Ohms @ 10 MHz; DC blocked
- 1 PPS Output
- Event Input
- Met/Tilt Sensor Support

POSITIONING PERFORMANCE[6]

Code Differential GNSS Positioning

Horizontal	0.25 m + 1 ppm RMS
Vertical	0.50 m + 1 ppm RMS
WAAS differential positioning accuracy[7]	
Horizontal	0.50 m RMS
Vertical	0.85 m RMS

Static GNSS Surveying

High-accuracy static	
Horizontal	3 mm + 0.1 ppm RMS
Vertical	3.5 mm + 0.4 ppm RMS
Static & Fast Static	
Horizontal	3 mm + 0.5 ppm RMS
Vertical	5 mm + 0.5 ppm RMS

Real Time Kinematic Surveying[8]

Single Baseline <30 km	
Horizontal	8 mm + 1 ppm RMS
Vertical	15 mm + 1 ppm RMS
Networked RTK	
Horizontal	8 mm + 0.5 ppm RMS
Vertical	15 mm + 0.5 ppm RMS
Initialization time	typically <10 seconds
Initialization reliability	typically >99.9%

COMMUNICATION

- Serial Ports
  - One D9 Male, EIA-574 RS-232/V.24 Full 9 wire serial
  - One Lemo 7 pin 0shell, 3 wire serial with power input, 1 PPS output and event input
  - One Mini B USB 5 pin; supports Device and Host mode operations
- Bluetooth[9]
  - Integrated 2.4 GHz Bluetooth; supports 3 simultaneous connections
- Ethernet
  - Integrated RJ45 jack
  - Full-duplex, auto-negotiate 100Base-T
  - Power over Ethernet (PoE) support with a Class 3 PoE supply
  - HTTP, HTTPS, TCP/IP, UDP, FTP, NTRIP Caster, NTRIP Server, NTRIP Client
  - Proxy server support
  - Routing table support
  - NTP Server, NTP Client support
  - UPnP and Zeroconf support
  - Email Alerts and File Push
  - Position Monitoring
  - IP Filtering

DATA LOGGING

Storage Capacity	
Onboard memory	8 GB
External memory[10]	greater than 1 TB
Maximum logging rate	50 Hz
File durations	5 minutes to continuous
Storage sessions	12 concurrent independent sessions with dedicated memory pooling and ring buffers
File formats	T02, RINEX v2.xx, RINEX v3.xx, BINEX, Google Earth KMZ
File naming options	multiple
Data retrieval and transfer	HTTP, FTP Server, USB, FTP Push and Email Push
Events	definable file protection on events

APPENDIX B - Trimble Alloy spec sheet

Alloy

GNSS REFERENCE RECEIVER

THE FUTURE OF GNSS IS HERE

Trimble's all-new Alloy GNSS receiver offers powerful performance with the latest GNSS technology in a sleek new design that is easy and intuitive to use. Whether you need GNSS for campaign work or in permanent installations, the flexible configuration delivers reliable, robust data when and where you need it.

MODERNIZED GNSS TRACKING

Using powerful Trimble 360 receiver technology in combination with dual Trimble Maxwell™ 7 chipsets, the Alloy GNSS receiver supports all known and planned GNSS constellations, ensuring your GNSS data is robust and reliable.

INTELLIGENT DESIGN

Review Key Info at a Glance

With a four-line angled display you can read all important information such as satellite tracking, position solution type, data logging, IP address, Wi-Fi®, firmware information and battery status right on the home screen. Set-up and verifying status information is now quick and easy.

Plug in and get to work

Multiple ports are easily accessible without the need for adaptors in a configuration that makes it simple to plug in a variety of external sensors and antennas.

Power when you need it

Alloy provides the most robust power options for any GNSS system. Featuring multiple power inputs with dual hot-swappable batteries, power over Ethernet, and advanced power management features, the Trimble Alloy GNSS receiveris ideal for any GNSS base station deployment.

Stackable Design

With a versatile, stackable design the Alloy GNSS receiver is built with a lightweight rugged aluminum alloy chassis which features IP68 certification. When you need to organize multiple units for deployment, simply stack and prep.

CONFIGURABLE ALERTS 24/7

Using Trimble Sentry™ technology, you can easily configure alerts that will automatically inform you of any changes to the position, data logging, configuration, tracking, power, communications, and system access events. Combined with advanced security measures such as IP filtering and multi-level user access, Trimble Sentry ensures continued operation of your Trimble Alloy GNSS receiver.

TRIMBLE RTX ON BOARD

The Alloy GNSS receiver is available with Trimble RTX™ advanced positioning technology allowing for rapid real-time network coordination. Whether this is for base station deployment or monitoring, Trimble RTX remains locked onto your real world absolute position.

COMMUNICATION

The Trimble Alloy GNSS receiver supports a wide range of communication protocols including Ethernet, Bluetooth®, and Wi-Fi for flexible easy access via the built-in Web User Interface and mini-Web User Interface for mobile devices.

DATA

Storage

The Alloy GNSS receiver is able to store more data in less space by using specialized compression formats. Up to twelve independent high-rate data logging sessions can be stored internally, and using USB storag you can be sure the data you collect and store is specific for your application.

Access

Leveraging advanced communication protocols, data can be accessed via the user interface, built in FTP Server, or configured to be pushed to remote FTP sites or email accounts in multiple industry formats.

Benefits

- Dual Trimble Maxwell 7 chipsets combined with a powerful processor provides the ultimate in tracking and processing power
- Ethernet and Wi-Fi support provide ease of access, configuration, and transfer of data. Using the built-in Web user interface gives instant access to a simple to use configuration suite
- Dual hot-swappable internal batteries with integrated charging make Alloy suitable for use in the office or remote locations, and anywhere in-between
- The intelligent design features multiple connectors and stackable housing, making Alloy easy to configure for deployment
- Designed to an IP68 certification Alloy is ready for any environment
- Includes firmware for life so it's easy to keep your Alloy reference receiver up-to-date with the latest features, enhancements and security updates, free to install from **www.alloy.trimble.com**

SPECIFICATIONS[1]

GNSS TECHNOLOGY

- Trimble RTX World-Wide Corrections
- Advanced Trimble dual Maxwell™ 7 GNSS chipset provide 672 channels for simultaneous satellite tracking
- Trimble EVEREST*Plus*™ multipath signal rejection
- Trimble 360 receiver technology
- High precision multiple correlator for GNSS pseudorange measurements
- Spectrum Analyzer to troubleshoot GNSS jamming
- Unfiltered, unsmoothed pseudorange measurements data for low noise, low multipath error, low time domain correlation and high dynamic response
- Very low noise GNSS carrier phase measurements with <1 mm precision in a 1 Hz bandwidth
- Signal to Noise ratio reported in dB-Hz
- Proven Trimble low elevation tracking technology
- Proprietary Receiver Autonomous Integrity Monitor (RAIM) system to detect and reject degraded signals to improve position quality

SATELLITE TRACKING

- GPS: L1 C/A, L2E (L2P), L2C, L5
- GLONASS: L1 C/A[2] and unencrypted P code, L2 C/A and unencrypted P code, L3 CDMA
- Galileo: L1 CBOC, E5A, E5B & E5AltBOC, E6
- BeiDou: B1, B2, B3
- QZSS: L1 C/A, L1C, L1 SAIF, L1S[3] , L2C, L5, LEX/L6[4]
- IRNSS: L5, S-Band
- SBAS: L1 C/A (EGNOS/MSAS), L1 C/A and L5 (WAAS)
- L-Band: Trimble RTX™

INPUT/OUTPUT FORMATS

- Correction Formats:
  - CMR, CMR+, CMRx, GAGAN, RTX, RTCM 2.x, RTCM 3.x, SDCM
- Observables:
  - RT17, RT27, BINEX, RTCM 3.x
- Position/Status I/O:
  - NMEA-0183 v2.30, GSOF
- Up to 100 Hz Output
- 10 MHz External Frequency Input
  - Normal input level 0 to +13 dBm
  - Maximum input level +17 dBm, ±35 V DC
  - Input impedance 50 Ohms @ 10 MHz; DC blocked
- 1 PPS Output
- Event Input
- Met/Tilt Sensor Support

POSITIONING PERFORMANCE

Differential Positioning

Code differential GNSS positioning[5]	
Horizontal	0.25 m + 1 ppm RMS
Vertical	0.50 m + 1 ppm RMS
SBAS differential positioning accuracy[6]	
Horizontal	0.50 m RMS
Vertical	0.85 m RMS

Static GNSS Surveying[5]

High Accuracy Static	
Horizontal	3 mm + 0.1 ppm RMS
Vertical	3.5 mm + 0.4 ppm RMS
Static & Fast Static	
Horizontal	3 mm + 0.5 ppm RMS
Vertical	5 mm + 0.5 ppm RMS

Real Time Kinematic Surveying[5]

Single Baseline < 30km	
Horizontal	8 mm + 1 ppm RMS
Vertical	15 mm + 1 ppm RMS
Networked RTK[7]	
Horizontal	8 mm + 0.5 ppm RMS
Vertical	15 mm + 0.5 ppm RMS
Initialization time	typically <10 seconds
Initialization reliability	typically >99.9%

COMMUNICATION

- Serial Ports:
  - Two 9-pin Male
  - Two 7-pin Lemo
- USB: one Mini-B USB 5-pin / RDNIS (Device and Host modes)
- Ethernet: one RJ45 (Full-duplex, auto-negotiate 100Base-T)
  - HTTP, HTTPS, TCP/IP, UDP, FTP,NTRIP Caster, NTRIP Server, NTRIP Client
  - Proxy server, Routing table, NTP Server, NTP Client support
  - Email Alerts and File Push
- WiFi: 802.11 b/g, access point and client mode, WPA/WPA2/WEP64/WEP128 encryption
- Bluetooth[8]: Integrated 2.4 GHz Bluetooth; supports 3 simultaneous connections

1 Specifications subject to change without notice.
2 L2 C/A on GLONASS-M satellites.
3 Plan to support L1S in 2018 after fully operational in satellite.
4 LEX / L6 supported on QZSS Block I satellites.
5 Accuracy may be subject to degradation by multipath interference, obstructions, satellite geometry and atmospheric conditions. Always follow recommended survey practices.
6 Depends on WAAS/EGNOS system performance.
7 Networked RTK PPM values are reference to the closest physical base station.
8 Bluetooth type approvals are country specific.

DATA LOGGING

Storage Capacity:	
Onboard Memory (Journaling)	up to 24 GB[9]
External Memory[10]	greater than 1 TB
Maximum Data Logging Rate	100 Hz
Maximum Combined Data Logging Rate	188 Hz
File Durations	1 minute to continuous
Storage Sessions	12 concurrent independent sessions with dedicated memory pooling
File Formats	T02, T04, BINEX, RINEX v2.x/3.0x, Google Earth KML/KMZ
File Naming Conventions	Multiple
Data Retrieval and transfer	HTTP, FTP Server, USB
Events	Definable file protection on events

PHYSICAL SPECIFICATIONS

Alloy receiver dimensions (W x L x H L x W x H)	20.98 cm x 21.36 cm x 7.62 cm (8.41 in x 8.26 in x 3 in)
Alloy receiver dimensions with brackets attached (L x W x H)	26.77 cm x 21.36 cm x 8.3 cm (8.41 in x 10.54 in x 3.27 in)
Weight	2.34 kg (5.17 lbs)

ENVIRONMENT

Operating Temperature[11]	–40 °C to +65 °C (–40 °F to +149 F)
Storage temperature	–40 °C to +80 °C (–40 °F to +176 F)
Humidity	100% condensing
Shock	
Operating	40 g per MIL-STD-810G Table 5.16.6-VII
Non-Operating	75 g per MIL-STD-810G Table 5.16.6-VII Designed to survive 1m bench drop
Vibration	
Operating	MIL-STD-810G Fig. 5.14.6C-1 Category 4
Ingress protection	IP68 Certified per IEC-60529 - waterproof/dustproof (1m submersion for 1 hr)

USER INTERFACE

- Front Panel Display
  - 4-line x 32 character reversible OLED display
  - 7 button input configuration
  - Adjustable LED backlighting
- Multiple language support for front panel and web UI - Chinese, Dutch, English, Finnish, French, German, Italian, Japanese, Norwegian, Polish, Portuguese, Russian, Spanish, Swedish
- Web User Interface: Allows remote configuration, data retrieval, and firmware updates over HTTPS/HTTP

ANTENNA SUPPORT

Output Voltage	5 V DC nominal
Maximum output current	150 mA
Maximum cable loss	12 dB
Recommended antennas	Trimble Zephyr 3 Geodetic, Trimble GNSS-Ti v2 Choke Ring, Trimble GNSS Choke Ring

SECURITY

- HTTP login
- HTTPS/SSL
- Programmatic Interface authentication
- NTRIP
- IP Filtering

ELECTRICAL

- Power over Ethernet (PoE) 802.3af (Type 1), 802.at (Type 2)
- 9.5 to 28 V DC input on 2 Lemo ports
  - User-configurable power-on voltage
  - User-configurable power-down voltage
- User-configurable 12 V DC power output on serial port #2
- Integrated dual hot-swappable smart batteries (7.4 V, 7800 mA-hr, Li-Ion batteries) with up to 15 hours of continuous operation
- Seamless switching between external/internal power sources
- Configurable minimum input voltage for battery charging
- Integrated battery charging circuitry
- Power Consumption – 3.8 W or higher, dependent on user settings

REGULATORY COMPLIANCE

- FCC Part 15 (Class B device), CISPR 32, 24
- RED CE Mark
- RCM
- UN 38.3 – ST/SG/AC.10/27/Add.2 Rev.5 (Li-Ion battery)
- IEC 62133(Ed.2) and EN 62133: 2013 (Li-Ion battery)
- RoHS, China RoHS, WEEE

9 Trimble's highly efficient T02 data logging format makes this equivalent to 32 GB to 55 GB for competitive receivers.
10 Solid state drives are recommended for optimal performance.
11 To protect the removable Li-ION batteries from extreme temperatures, the internal battery charger only charges batteries from –20 C to +50 C (–4 °F to +122 °F).

APPENDIX C - Zephyr Geodetic antenna spec sheet

Specifications	Trimble Zephyr 3 Geodetic Antenna	Trimble GNSS-Ti v2 Choke Ring Antenna	Trimble GNSS v2 Choke Ring Antenna
Minimum tracking elevation	0 Degrees	0 Degrees	0 Degrees
Practical tracking elevation	<3 Degrees	<5 Degrees	<5 Degrees
Supported positioning signal bands	L1/L2/L5/G1/G2/G3/E1/E5ab/E6/B1/B2/B3	L1/L2/L5/G1/G2/G3/E1/E5ab/E6/B1/B2/B3	L1/L2/L5/G1/G2/G3/E1/E5ab/E6/B1/B2/B3
Supported SBAS signal bands	WAAS, EGNOS, QZSS, Gagan, MSAS, OmniSTAR®, RTX™	WAAS, EGNOS, QZSS, Gagan, MSAS, OmniSTAR, RTX	WAAS, EGNOS, QZSS, Gagan, MSAS, OmniSTAR, RTX
Phase-center accuracy	2 mm or better	2 mm or better	2 mm or better
Phase-center repeatability	<1 mm	<1 mm	<1 mm
Maximum phase-center eccentricity	2 mm	2 mm	2 mm
Antenna gain	50 dB ±2dB	50 dB ±2dB	50 dB ±2dB
LNA features	Trimble's advanced second generation filtering to reduce interference by nearband transmitters	Trimble's advanced second generation filtering to reduce interference by nearband transmitters	Trimble's advanced second generation filtering to reduce interference by nearband transmitters
LNA signal margin	13 dB	13 dB	13 dB
Supply voltage	3.5 V DC to 20 V DC	3.5 V DC to 20 V DC	3.5 V DC to 20 V DC
Supply current (maximum)	125 mA	125 mA	125 mA
Power consumption (maximum)	440 mW – 700 mW	440 mW - 700 mW	440 mW - 700 mW
Dimensions	34.3 cm diameter x 9.3 cm height 13.5 in diameter x 3.66 in height	38 cm diameter x 14.6 cm height 15 in diameter x 5.75 in height	38 cm diameter x 14 cm height 15 in diameter x 5.5 in height
Weight	1.36 kg (3 lb)	4.3 kg (9.5 lb)	4.3 kg (9.5 lb)
Element type	Dual four-point-feed patch	Dual four-point-feed patch	Phase-ripple-tested Dorne & Margolin AIL C-146
Polarization	Enhanced right-hand circular	Enhanced right-hand circular	Right-hand circular
Axial ratio	2 dB at Zenith	2 dB at Zenith	2 dB at Zenith
Voltage Standing Wave Ratio	2.0 maximum	2.0 maximum	2.0 maximum
Left-hand circular polarization (LHCP)	20 dB minimum	20 dB minimum	20 dB minimum
RoHS compliant	Yes	Yes	No
Multipath mitigation technologies	LHCP rejection and resistive ground plane	LHCP rejection and 1/4 wave choke ring ground plane	LHCP rejection and 1/4 wave choke ring ground plane
Ground plane design	Trimble Stealth resistive	JPL designed 1/4 wave choke ring	JPL designed 1/4 wave choke ring
Coaxial connector	TNC Female	N Female	N Female
External radome	46291-00 available	59314 available/recommended	59314 available/recommended
Shock rating	2 m (6.56 ft) drop	1 m (3.28 ft) drop	1 m (3.28 ft) drop
Vibration rating	MIL-STD-810-F on each axis	4.3 GRMS, random vibration profile; Z axis only	4.3 GRMS, random vibration profile; Z axis only
Humidity	100% humidity proof, fully sealed	100% humidity proof, fully sealed	100% humidity proof, fully sealed
Temperature Operating Storage	 –55 °C to +85 °C (–67 °F to 185 °F) –55 °C to +85 °C (–67 °F to 185 °F)	 –55 °C to +85 °C (–67 °F to 185 °F) –55 °C to +85 °C (–67 °F to 185 °F)	 –55 °C to +85 °C (–67 °F to 185 °F) –55 °C to +85 °C (–67 °F to 185 °F)
Mounting thread	5/8"–11 Female	5/8"–11 Female	5/8"–11 Female

Appendix D - RV50 Datasheet

Sierra Wireless
AIRLINK RV50X

	Specification
HOST INTERFACES	10/100/1000 Ethernet (RJ45)
	RS-232 serial port (DB-9)
	USB 2.0 Micro-B Connector
	3 SMA antenna connectors (primary, diversity, GPS)
	Active GPS antenna support
INPUT/OUTPUT	Configurable I/O pin on power connector • Digital Input ON Voltage: 2.7 to 36 VDC • Configurable Pull-up for dry contact input • Digital Open Collector Output > sinking 500 mA • Analog Input: 0.5-36 VDC
LAN (ETHERNET/USB)	DNS, DNS Proxy
	DHCP Server
	IP Passthrough
	VLAN
	Host Interface Watchdog
	PPPoE
SERIAL	TCP/UDP PAD Mode
	Modbus (ASCII, RTU, Variable)
	PPP
	DNP3 Interoperability
NETWORK AND ROUTING	Network Address Translation (NAT)
	Port Forwarding
	Host Port Routing
	NEMO/DMNR
	VRRP
	Reliable Static Route
	Dynamic DNS
	Policy Routing
	Verizon ANTM
	IPv6 Gateway
VPN	IPsec, GRE, and OpenVPN Client
	Up to 5 concurrent tunnels
	Split Tunnel
	Dead Peer Detection (DPD)
	Multiple Subnets
EVENTS ENGINE	Custom event triggers and reports
	Configurable interface, no programming
	Event Types: Digital Input, Network Parameters, Data Usage, Timer, Power, Device Temperature and Voltage
	Report Types: RAP, SMS, Email, SNMP Trap, TCP (Binary, XML, CSV)
	Event Actions: Drive Relay Output
DIMENSIONS	119 mm x 34 mm x 85 mm (94 mm including connectors)
	4.69 in x 1.34 in x 3.35 in (3.70 in including connectors)
SECURITY	Remote Authentication (LDAP, RADIUS, TACACS+)
	DMZ
	Inbound and Outbound Port filtering
	Inbound and Outbound Trusted IP
	MAC Address Filtering
	PCI compatible
APPLICATION FRAMEWORK	ALEOS Application Framework (AAF)
	LUA Scripting Language
	Eclipse-based IDE
	Integrated with AirVantage®
	Dual-Core Processing

	Specification
SATELLITE NAVIGATION (GNSS)	12 Channel GPS and GLONASS Receiver
	Acquisition Time: 1 s Hot Start
	Accuracy: <2 m (50%), <5 m (90%)
	Tracking Sensitivity: -145 dBm
	Reports: NMEA 0183 V3.0, TAIP, RAP, XORA
	Multiple Redundant Servers
	Reliable Store and Forward
NETWORK MANAGEMENT	Secure network management applications available in the cloud or licensed platform in the enterprise data center
	Fleet wide firmware upgrade delivery
	Router configuration and template management
	Router staging over the air and local Ethernet connection
	Over-the-air software and radio module firmware updates
	Device Configuration Templates
	Configurable monitoring and alerting
	Remote provisioning and airtime activation (where applicable)
GATEWAY MANAGEMENT INTERFACES	ALMS
	Local web user interface
	AT Command Line Interface (Telnet/SSH/Serial)
	SMS Commands
	SNMP
POWER	Input Voltage: 7 to 36 VDC
	LTE Idle Power: 900mW (75 mA @ 12VDC)
	Standby Mode Power: 53 mW (4.4 mA @ 12 VDC) triggered on low voltage, I/O or periodic timer
	Low voltage disconnect to prevent battery drain
	Built-in protection against voltage transients including 5 VDC engine cranking and +200 VDC load dump
	Ignition Sense with time delay shutdown
	Configurable features and ports to optimize power consumption
ENVIRONMENTAL	Operating Temperature: -40°C to +70°C / -40°F to +158°F
	Storage Temperature: -40°C to +85°C / -40°F to +185°F
	Humidity: 90% RH @ 60° C
	Military Spec MIL-STD-810G conformance to shock, vibration, thermal shock, and humidity
	IP64 rated ingress protection
INDUSTRY CERTIFICATIONS	Safety: IECEE Certification Bodies Scheme (CB Scheme), UL 60950
	Vehicle Usage: E-Mark (UN ECE Regulation 10.04), ISO7637-2, SAE J1455 (Shock & Vibration)
	Hazardous Environments: Class 1 Div 2
	Environmental: RoHS, REACH, WEEE
SUPPORT AND WARRANTY	Includes 1st Year AirLink Complete: • AirLink Management Service (ALMS) • Direct 24/7 Technical Support • 3-year standard warranty; optional 2-year warranty extension 1-day Accelerated Hardware Replacement available through participating resellers
ACCESSORIES	In the Box: DC Power Cable and Quick Start Guide Other Accessories (sold separately): 2000579 AC Adapter, 12VDC 6000659 DIN Rail Bracket For antenna options visit: sierrawireless.com/antennas